DISCUSSION ON HARBORS

BY

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Mr. Haupt.

LEWIS M. HAUPT, M. AM. SOC. C. E., Philadelphia, Pa.—The
cessity of determining the direction of the resultant drift is
ndamental, as stated by Mr. Le Conte and as mentioned in Major
illette's paper, for it furnishes the key to the successful improve-
ent of ocean bars at much less cost. The difficulties of determining
is fundamental question are shown by Major Gillette himself in
e several reports he has submitted on this subject. In the final
port on the Brunswick Bar,* made in 1901, to Congress, it is
ated that the prevailing winds, and the waves and currents gen-
ated thereby, drive the channel to leeward. "This is the almost

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* House Doc. No. 355, Fifty-sixth Congress, 2d Sess., pp. 3–4.

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Mr. Haupt. invariable history of all such bars. * * * The prevailing winds and a predominance of the storms are from the northeast." As a consequence, Major Gillette concluded that if the channel were held in place by a jetty placed to "leeward," so that it could not swing away from this drift, the currents would be forced against the jetty by the advancing sand bank and the channel would be created on the windward side thereof, for the above-mentioned report states:†

"The channel location thus being fixed, Nature may be expected to deepen it, and is assisted in this respect by the fact that the jetty cuts off a considerable escape of the tidal flow, which, added to the water normally flowing through the channel, would be expected to create greater depths. This principle requires the jetty to be located upon that side of the channel toward which the latter is being driven by the drifting sands. To use a phraseology analogous to that which has been used in other cases, it would be on the 'leeward' of the channel.

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"A single jetty on this principle at Brunswick would be located on the south of the channel, since the drifting sands come from the north. * * * At this place * * * the drift * * * is an enormous sand bank which moves and which always moves very positively in one direction."

Major Gillette is, therefore, to be congratulated for the frank change of front which he makes in his present paper where, under the head of "Protection," he says:

"In bar improvement by concentrating jetties, the defence of the channel against drifting sand is a vital element in the problem.

"The jetty on the side from which comes the resultant sand drift is the more important. This has been called the 'windward' jetty. * * * not with reference to the wind, but to the resultant sand drift. Practically it applies to the prevailing wind also, for, as indicated above, cases in which the prevailing on-shore wind and the sand drift do not agree * * * are exceedingly rare."

Again, under "Wind Records," it is said:

"The sand drift being almost invariably with the wind, the record of such winds as cause breakers strong enough to stir up the sand is, perhaps, the best-known index of the sand movement. * * * From a careful study of the above facts, in any particular case, a safe deduction as to the direction of the resultant drift can generally be made."

Yet in the face of these general facts as now accepted by Major Gillette, he cites the single exception of Aransas Pass, where he says:

"The entrance has moved south a long distance against the resultant drift, and work is now going on there, on the theory that the drift is from the north, whereas it appears to be distinctly from the south."

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† House Doc. No. 355, Fifty-sixth Congress, 2d Sess., pp. 18–19.

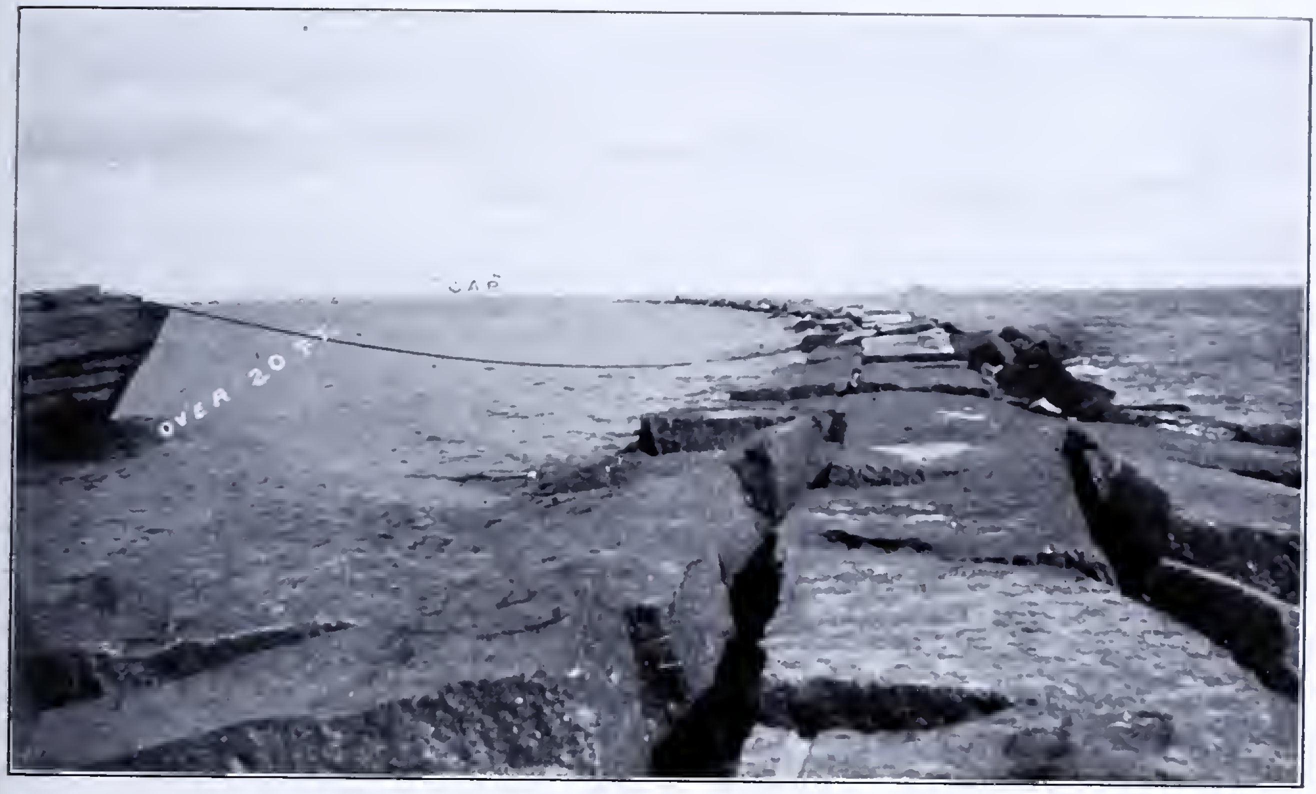

FIG 1.—REACTION BREAKWATER AT ARANSAS PASS.

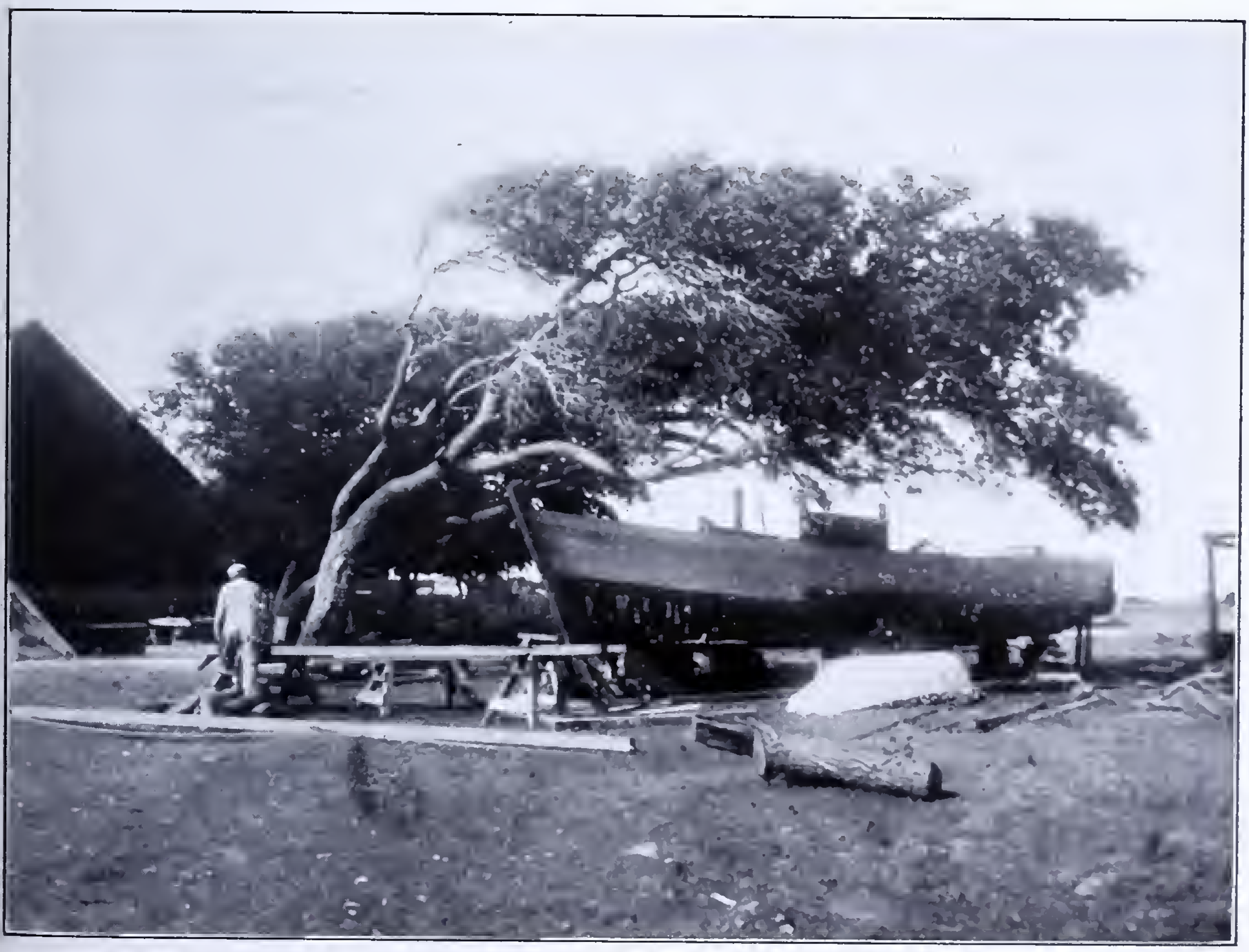

FIG. 2.—TREE AT ROCKPORT, TEXAS, SHOWING PREVAILING WIND FROM THE SOUTHEAST.

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Thus this vital issue crops out again as it did in the report on the Brunswick Bar, and, as its truth or error affects the economic solution of this class of harbor works, it is worthy of a dispassionate discussion.

Fortunately for Major Gillette's contention, this illustration covers both horns of the dilemma, for if, as he now asserts, the "windward" jetty is the more important one (which is undoubtedly true) and the resultant drift is from the south, then the old Government jetty built out about one mile into the Gulf and on that (the south) side of the entrance, prior to 1885, should have deepened the channel by intercepting the drift on its "windward" side. Unfortunately for the argument, the sand gathered on its northern or leeward side and was dropped in the channel, thus blocking it up, and the bar advanced seaward as fast as the jetty was extended, so that the official reports stated the deepening to have been insignificant and the work was abandoned to private parties. Similar results were produced by building the south jetties first at other Gulf ports.

On the other hand, if the drift is from the northeast and the jetty, now adopted by Congress and nearly completed, is correctly located between its source and the channel, then there should be an improvement, as there is; for in the lee of the completed work the depths are more than 20 ft. at mean low water and with only a portion of the tidal volume under control (see Fig. 1, Plate XXXI). Moreover, if the drift be due to the prevailing winds, it will be found far more reliable to trust to the physical record on the site, which is the result of centuries, than to go to the register of any Bureau and attempt to formulate their observations. Why should this entrance have moved over 2 miles in 40 years "against the resultant drift" when all other inlets move with it? A body does not move toward the force impelling it. But if further evidence be needed as to these effects of the southeast trades at this entrance, a glance at the vegetation in that section, as illustrated in Fig. 2, Plate XXXI, should leave no doubt as to the general direction and intensity of the winds along this coast. This view is looking south-southwest, which is about at right angles to the axis of the foliage, thus indicating a strong east-southeasterly wind. The U. S. Coast Survey Officer, in reporting on this entrance in 1899, said:

> "That the resultant current is from the north is shown by the lengthening in former years of St. Josephs Island on the south end, by the accumulation of sand carried from the north and by the washing away of Mustang Island on its north end."

In view of these observations as to the facts from disinterested authorities and especially from the deepening which has resulted from the construction of the work, even during the prevalence of the

Mr. Haupt. summer drift from the southwest, there would seem to be no room for doubt as to the correctness of the theory and location of the breakwater at this point.

It is remarkable, therefore, that on page 310, in discussing the propriety of leaving "a gap" at the shore end to admit the flood tide freely, Major Gillette should state that, although there has been no material change in the floor of the sea in consequence of the currents and waves passing through this breach of 2 000 ft., it is because:

> "The tidal range here is small, and the sand drift, while moderate in quantity, is undoubtedly to the north in the aggregate, and seems to be so in detail, seldom or never moving to the south."

And he calls this a "lee jetty," whereas it is, in view of Nature's evidence, a windward breakwater.

The above statement that there is but a moderate quantity of drift and that it is seldom or never moving to the south may, perhaps, best be weighed by quoting Major Gillette's views as given in his Brunswick Bar Report, which devotes large space to the discussion of the work at Aransas Pass, in which this statement occurs:*

> "The writer is of the opinion that, while there is a movement at different times in each direction, the great preponderance of the drift is from south to north, and that the jetty is located in direct contradistinction to this primary principle of the theory. The testimony upon this subject is quite conflicting, but a careful analysis will show that the resultant movement is very large and is to the northward."

How are these conflicting statements to be construed in the face of the fact that the inlet has been driven more than 2 miles to the southward within 40 years and has left, in its wake, a train of sand of that length and nearly 1 mile in width? Was it possible for this very great deposit to come up from the south, jump across the channel and settle on the lee side, thus pushing the inlet backward upon itself? If so, it was an unprecedented phenomenon of Nature.

Twin Jetties.—But failing to account for the unprecedentedly good results of the single curved breakwater at Aransas Pass in any other way, Major Gillette, on page 320, states:

> "At Aransas Pass, Texas, twin jetties have been partially constructed, the 'lee' jetty being constructed far in advance of the other as the bar was approached. In both cases the drift has passed the line of the windward jetty which is yet low and incomplete. Very little improvement of the bar has resulted * * *."

To support this assumption of twin jetties at Aransas Pass, Major Gillette stated:†

"The first of these jetties—the north one—is composed of two

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* House Doc. No. 355, Fifty-sixth Congress, 2d Sess., p. 24.

† House Doc. No. 355, Fifty-sixth Congress, 2d Sess., p. 28.

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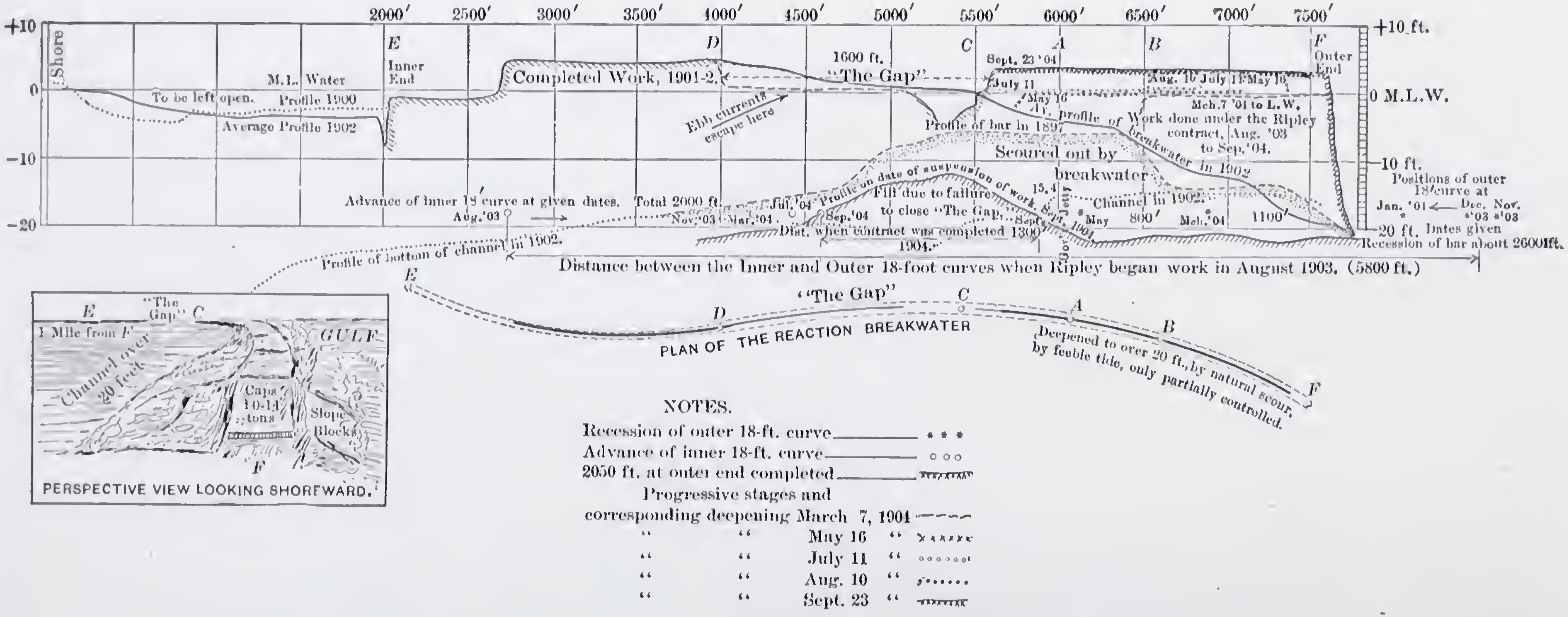
+10
0
−10
−20
2000′
2500′
3000′
3500′
4000′
4500′
5000′
5500′
6000′
6500′
7000′
7500′
+10 ft.
0 M.L.W.
−10 ft.
−20 ft.
Shore
E
Inner End
D
C
A
B
F
Outer End
M.L. Water
To be left open.
Profile 1900
Average Profile 1902
Completed Work, 1901-2.
1600 ft.
"The Gap"
Ebb currents escape here
Sept. 23 '04
July 11
May 16
Aug. 10 July 11 May 16
Mch. 7 '04 to L.W.
Av. Profile of breakwater in 1902
Work done under the Ripley contract, Aug. '03 to Sep. '04.
Profile of bar in 1897
Scoured out by breakwater
Profile on date of suspension of work, Sept. 1904
Fill due to failure to close "The Gap"
15.4
Gov. Jetty
Channel in 1902.
May
800′
Mch. '04
1100′
Positions of outer 18′ curve at
Jan. '01
Dec. '03
Nov. '03
Dates given
Recession of bar about 2600 ft.
Advance of inner 18′ curve at given dates.
Total 2000 ft.
Aug. '03
Nov. '03
Mar. '04
Jul. '04
Sep. '04
Dist. when contract was completed 1300′ 1904.
Profile of bottom of channel in 1902.
Distance between the Inner and Outer 18-foot curves when Ripley began work in August 1903. (5800 ft.)
E
D
"The Gap"
C
A
B
F
PLAN OF THE REACTION BREAKWATER
Deepened to over 20 ft., by natural scour, by feeble tide, only partially controlled.
E
"The Gap"
C
1 Mile from F
GULF
Channel over 20 feet
Caps 10-14 tons
Slope Blocks
F
PERSPECTIVE VIEW LOOKING SHOREWARD.
NOTES.
Recession of outer 18-ft. curve
Advance of inner 18-ft. curve
2050 ft. at outer end completed
Progressive stages and corresponding deepening March 7, 1904
" " May 16 "
" " July 11 "
" " Aug. 10 "
" " Sept. 23 "

Exhibit showing the "conditions" existing at Aransas Pass, Texas, when the work was suspended under the provisions of the Act appropriating $3 000 000 "for the restoration or maintenance of channels."

Here there has been a remarkable deepening where the breakwater was completed and a shoaling of over 10 ft. where it was not. The bar has been narrowed 80% solely by the action of the breakwater on the currents and the control of the drift.

There would appear to be no other "legal" way to restore and maintain the channel than to close the gap and complete the structure, as enacted by Congress for the purpose of demonstrating the great utility and economy of this system, immediately.

The "conditions," then, would justify the closure of the gap and the opening of a 20 ft. navigation.

Mr. Haupt. parts, one of which is a natural bank extending from St. Josephs Island to the inner end of the breakwater."

Again:

"The trend of the currents being such that no artificial structure is needed here to maintain this."

One would naturally infer that there exists a "natural bank" or dike here to obstruct the discharge, yet in the paper now under discussion it is frankly stated:

"A gap at the shore end of this is not even provided with a sill. Apparently it has not scoured appreciably."

The Government plan of two jetties contemplates closing this so-called gap (which is 2 000 ft. long, left as a part of the plan to admit the tides which alone are available for scour) which would, therefore, be a fatal error (see Fig. 24).

To constitute the second jetty, Major Gillette regards as a jetty the head of Mustang Island, which overlaps the breakwater, and the submerged Government work, which, in 1885, or thereabouts, was reported as having "disappeared," being buried under the sand by the cross-currents, the channel having crossed the jetty. It should be noted that, in this paper, this submerged structure is characterized as an efficient jetty, while on page 317, in referring to the 4¼-mile jetty, built in large part above the high-water plane, and which served as an effective nucleus for the formation of a sand-spit of the same length, he says: "The work done is not properly a jetty at all." This, notwithstanding the fact that it shifted the channel about 3 miles and caused the gorge as well as the bar to move seaward about 1 mile. And again, on page 316, he also states:

"Under the protection of this jetty, the river promptly built up its south bank, part of it to high water * * *. But the fact that the river cuts a channel with a steep bank, building up its own bank inside the jetty, is due to the protection of the area by the jetty."

One is led to believe, therefore, that it is a jetty after all, and has had a very material effect, as such, in impounding the drift, shifting the channel and advancing the bar without ultimate increase in depth, at the mouth of the Columbia River.

The Nelson jetty, built on the south side of Aransas Pass, was but a repetition of the former experience and met with the same fate, and no effective part of it was left standing at the time Major Gillette cited it as operating as a jetty in co-operation with the breakwater. There is to-day no other structure at that inlet which can be said to form a second jetty, and there has not been since this work was started in 1895.

Bar Advance.—If the projection of the silt forward into the channel can be prevented, there will be no bar advance, and it was part of the design of the concave breakwater to accomplish this purpose by causing a lateral or transverse movement of the sand to form an automatic spit on the convex bank, which would adjust itself to the regimen of the prevailing conditions. This has been denied by Major Gillette, even in this latest paper, as well as in the Brunswick Bar Report to Congress. Mr. Haupt.

The speaker requested permission to publish an official reply thereto, but it was denied, so that his discussion will be found published in the *Proceedings* of the American Philosophical Society, Vol. XL, for 1901, and need not be dwelt upon here further than to call attention to the progress chart, Fig. 24, as evidence that there has been no bar advance, but a recession of the 3-fathom curve of about ½ mile in less than 1 year, as the work proceeded, and, had it not been suspended by the failure to recommend an allotment from the present emergency bill, the full depth would have been in existence before the publication of this paper.

CUMBERLAND SOUND.

Again, while Major Gillette points with just pride to the very atisfactory improvements recently secured at Cumberland Sound, hey are due mainly to the rapid building up of the outer end of the windward jetty, thus forming a lee across the crest of the bar. But it is unfortunate that the old trace was followed, since the traight portion of the jetty retires from the effluent current and roduces no reaction nor continuous change of direction, so that he scouring and lateral transportation are not fully utilized, and, s a consequence, there has been serious bar advance as shown by he three charts (Figs. 21, 22 and 23) in Major Gillette's paper. In 900, the 6-fathom curve, abreast of the north channel, was about 2 600 ft. out; in 1902, it was 15 000 ft. out; and, in 1904, it was bout 16 500 ft. out, a total advance of nearly ¾ mile in, say, 4 years. his is not so at Aransas Pass, Fig. 24, where, on the contrary, the ecession is ½ mile in less than 1 year, and this difference in result due solely to the curvature which does what it was claimed it ould, and to the mode of construction which contemplated the ontrol of the outer currents first. All which features have been equently submitted to the Boards of Engineers, in connection with roposals for the opening of ocean bars elsewhere with guarantees depths since 1888, but which have not been made public by them or reported to Congress.

With the large bank lying between the jetties and the "enormous nd bank which always moves very positively in one direction," it ould seem that the windward jetty has not yet completely controlled e littoral drift and must needs be extended. But when it is, it ould be flexed to the southeastward, and if the shore end had

Mr. Haupt. been treated differently, so as not to attempt to interfere with th natural disposition of the drift, a permanent bar-crossing could stil readily be secured without the need of any part of the south or leeward jetty, the cost of which would be saved.

No human agency can destroy these forces of Nature and permanently prevent the littoral drift from traveling along the coast The problem is merely so to protect the bar-crossing as to preven the deposition of sand along its crest, by a reactionary structur which will cause such activity in the currents, locally, that the bottom will be cut out by them and that no other material shall tak its place so long as the reaction is maintained, that is, so long a the structure stands. By detaching it from the shore, therefor there is the least interference with the normal movements of th drift, and the entrance of the tides, while at the same time, the preponderance of the ebb tide is concentrated upon a more limite sector of the bar, which does not advance, but delivers whateve sand passes out to the leeward bank, where the natural forces agai pick it up for its journey down the coast to the next breach.*

A Single Windward Jetty.—Major Gillette cites the Columbia Ba as evidence that, even if complete in all its elements, such a jett will not permanently improve the bar, and attributes the deposit o the channel side to the large quantities of sand brought down b the river, causing "the channel to leave the jetty and wander aroun the north half of the bar with about the same freedom and the sam depth as without the jetty." In short, does this mean that a concentration of one-half has no beneficial effect on the depths? It i also to be noted in the diagram of the crest lines of the bars (Fig 2 and 3, Plate XXIV) that the crossing-point has moved northwardl some 2 miles between 1895 and 1902, due to the drift of the beac sand coming over from the south, and that it has likewise shoale from 34 to 24 ft., due to the protrusion of the bar seaward. Thes are not the ruling depths, however, but an average of a zone ½ mil in width. Then, applying the Aransas analogy, the Columbia jett must be to leeward of its channel or else the Aransas jetty is a tru windward one. Major Gillette records it as his opinion that singl windward jetties can never effect a permanent improvement an that it can confidently be expected that the channel will leave th jetty and return to its natural condition. These views are disproven at Aransas Pass, if it be regarded as a "windward jetty," which it has been shown to be, quite as much as that at the Columbi where the channel has drifted some 2 miles to the northward, in few years.

If the jetty be detached (see page 318), then it is stated:

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* For a fuller discussion of the Cumberland Bar, see *Transactions*, Am. Soc. C. E Vol. XXXVI, p. 133; Vol. XLVI, p. 507; *Engineering Magazine*, May, 1903, etc.

"The drift will go through the gap (at the shore end) and drive he channel away from the jetty long before the latter has had any hance to help develop a channel by arresting the littoral drift." Mr. Haupt.

But the report* says that it does not do so at Aransas Pass (be-un in 1895) and it overlooks the scouring out, not the formation, f the bar coincidently with the construction due to the building up f the outer end of the breakwater, so that the channel has not left the jetty," which serves as a breakwater and aid to navigation, cting as a visible beacon, on a very easy curve, whose radius is 600 ft.

The Columbia River Bar.

Twin Jetties.—The conditions requisite for success are said to two parallel or convergent jetties "built to high water throughout d extending across the bar from shore," but Major Gillette very rtinently adds, "the material scoured from between the jetties is posited just seaward of their ends where * * * it is likely form a new bar."

Applying these generalizations to the mouth of the Columbia iver, Plate XXII, independent of the cost, it will be seen that the tension of the windward jetty from Clatsop Spit does not reach en to the crest of the bar and that it is flexed away from the annel-crossing, so as not to support the currents so well as the rmer single-jetty project which it has supplanted. Moreover, it found by reference to the Report of the Board, of which Major llette was a member,† that the jetties are not to be high-water ructures, and still it is stated that:

> "No less extensive a project will assuredly secure and perma-ntly maintain a channel, 40 ft. deep and of suitable width."

This claim seems to be at variance with the conditions as above d down, and there is certainly no known precedent for it in the rld. Even to approximate the requirements of a pair of jetties aching to high water and extending across the bar to deep water uld make them cost about $7 500 000, whereas the present estimate $3 715 000, which is much above the limit fixed by the law (2 531 140.51). It is proper to add that this plan was the out-ne of a proposal to open this bar by natural scour and guarantee requisite channel at a cost of $2 500 000, but this project, sub-tted in June, 1902, is still reposing in the archives of the De-rtment. The result of the extension of the south jetty by building t will be a corresponding growth of the sand spit on the south, and, er the north jetty is built, a rolling of the bar farther out, h less depth than at present, because of the longer slope and the ension of the fresher river water as it passes seaward.

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[*] House Doc. No. 355, Fifty-second Congress, 2d Sess.

[†] Annual Report, Chief of Engrs., U. S. A., 1903, pt. 3.

Mr. Haupt. The most favorable conditions for channel formation by two jetties which have been properly designed, spaced and built at the mouths of large streams (which are the most favorable locations) are those at Tampico, resulting in 27 ft. at high water; the Sulina Branch of the Danube with 20 ft.; and the South Pass with 30 ft., but this latter has been secured at the expense of the entire pass above.

The topographic conditions at the mouth of the Columbia are well shown in Plate XXXII,* from which it will be seen that a single rocky headland, Pt. Ellice, operating upon only a portion of the stream, has bored, by reaction, to a depth of 100 ft. and transported a portion of the eroded material to the counterscarp, some ½ mile away, while it also operates to maintain a curved channel, having a radius of about 5 miles, for a length of 8 miles. With this natural evidence available, it may safely be predicted that a continuous resisting breakwater, extending a distance of 2½ miles across the bar, having a radius of 5 miles and so placed as to receive practically the whole of the effluent discharge, will cut a channel at least 40 ft. in depth and of ample width, which will be self-maintaining.

The Columbia River problem, therefore, is not a hopeless one, but it is not open to competition and will not be improved by the plans as submitted in the paper, either permanently or otherwise, without radical enlargements and at much greater cost.

The two jetties, two miles apart, cannot co-act to create a channel by scour, but will merely operate as a nozzle to project the ebb currents upon the inner slope of the bar, causing it to advance seaward, while the height is such as to permit a large portion of the sand to travel over in either direction and thus feed the channel and the bar from the littoral drift which is not excluded, thus neutralizing to a large extent the purpose of their construction. In view of the experience already available at this point, at the expense of some twenty years and of over $2 000 000, it would seem hardly justifiable to expend nearly $4 000 000 more to repeat a demonstration the effect of which should be so patent to all maritime engineers and which does not fulfil the requirements which Major Gillette has laid down as necessary to success, as derived from frequent failures elsewhere.

Notwithstanding the many conflicting conditions which Major Gillette mentions as existing, he nevertheless concludes,

"That there are only two methods of bar deepening that are adapted to the conditions that obtain in United States harbors. These are dredging and twin jetties * * *"

It may seem remarkable that the United States is limited to this

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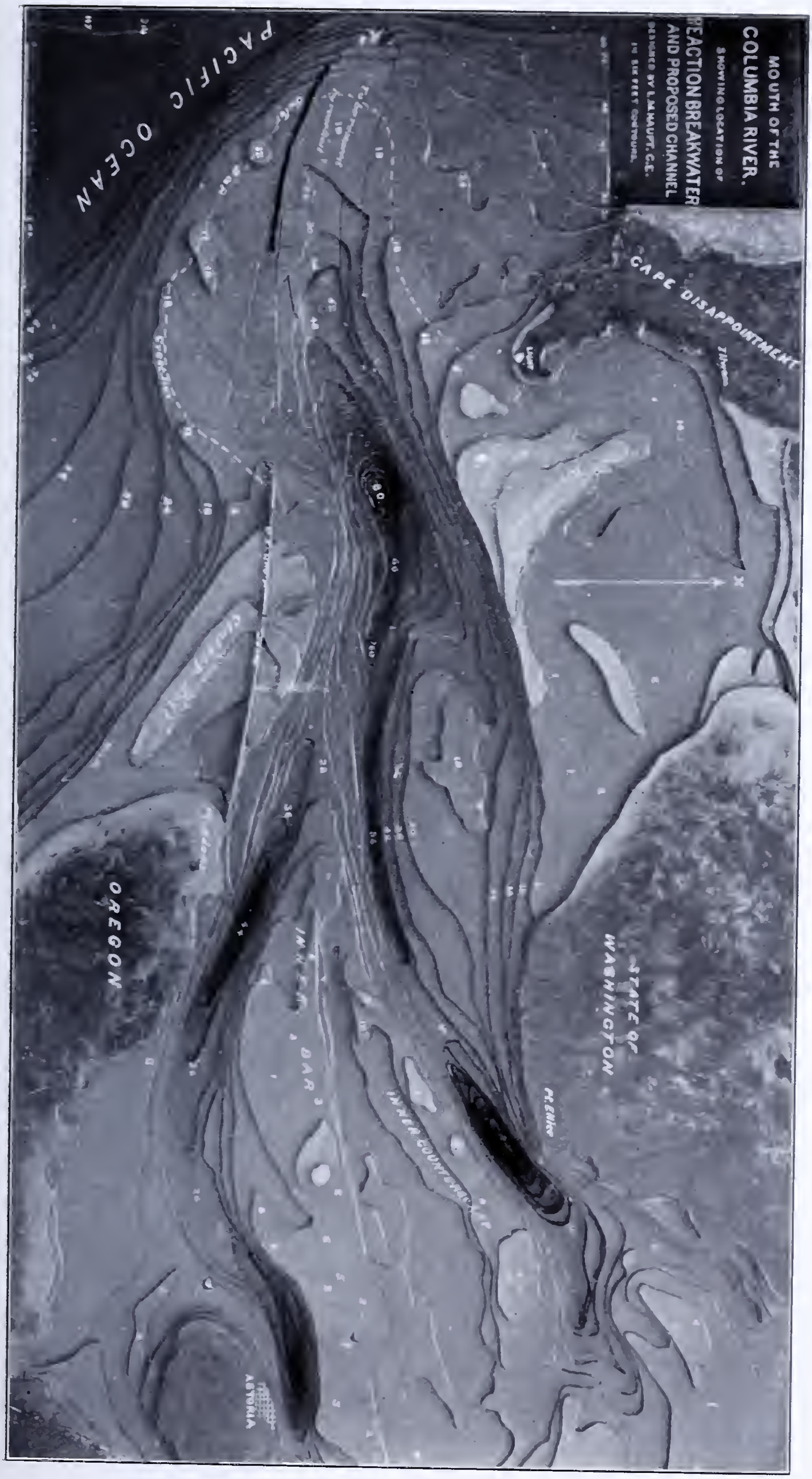
* Photographed from model, submitted to the Board of U. S. Engineers to consider and report upon the writer's proposal, but to which report he is denied access.

PLATE XXXII. VOL. LIV. PART A.
TRANS. AM. SOC. CIV. ENGRS.
INTER. ENG. CONG., 1904.
HAUPT ON
HARBORS.



Mr. Haupt.

narrow margin, especially when it is known that other methods have secured permanent deep-water channels, not only in this country, but elsewhere. This is admittedly the most expensive method, not only to construct, but to maintain, requiring more capacious dredging plants than any in existence to-day, and still the bars are not kept under control.

This method also necessitates the additional cost of extending the jetties to keep pace with the bar advance, which Major Gillette calls a "bogey" which has seemingly alarmed many theoretical writers on the subject, yet he introduces this remark by the admission that, "In computing the cost of permanent improvement by twin jetties allowance must be made for the initial scour 'pushing the bar seaward,'" and he follows it by the further admission, "There is no method yet devised, except possibly dredging, that will not 'push the bar seaward' and twin jetties * * * are doubtless the worst sinners in this respect."

It is only necessary to revert to the history of the South Pass jetties to see that the rate of bar advance has been greatly retarded in consequence of their construction, but at the expense of the Pass itself, and, especially, to note the recession of the bar at Aransas Pass, caused by the single reaction jetty to disprove utterly the above assertion that all methods push the bar seaward. Major Gillette evidently cannot appreciate the possibility of a lateral displacement of material by reaction from a concave directrix and the construction by natural agencies of a convex bank at a safe navigable distance therefrom. This is a vital element which has been overlooked in harbor bar problems and its acceptance does not seem o meet with favor as yet. Other channels have been improved by dynamite with dredging, but very few by dredging alone, as is now being undertaken in several instances.

Many other interesting points are suggested in this comprehenive paper, but these may suffice to show that the resources of the harbor engineer are not to be confined to twin jetties and dredging, f the most permanent and economical results are the objects to be ttained.

Referring to the paper by Mr. Vedel, the subject of island harors is an important one. Where there are detached rocks or islands near shore forming a shelter or lee, the area behind them ecomes a natural depository for the drift. Some notable instances ould be cited, as Richmond Island, Maine, where there is a large rocky island, also at Nantasket, Marblehead and other points in Massachusetts Bay, where similar shoals are formed, connecting with he mainland. Hence, it seems an important point for the artificial rotection of a harbor and for the arresting of littoral drift to construct such obstacles at a short distance from the shore. The

Mr. Haupt. distance is an important factor, as illustrated in case of several wrecks near shore, on the New Jersey coast. If too near the low-water line the waves are thrown over and produce erosion of beach, while when they are further out the wave action is checked and deposits take place, causing the sand to advance rapidly to the wreck. Hence it is very important to place the wave breaker some distance off shore rather than close to the beach. Grand Island, Lake Superior, is a notable natural, insular harbor, with comparatively little shoaling, because it has very little drift. Presque Isle on Lake Erie is a case in point. Various other harbors might be mentioned.